PATHOLOGICAL PHYSIOLOGY AND GENERAL PATHOLOGY

A STUDY OF THE HEMODYNAMICS DURING OXYGEN RESPIRATION UNDER EXCESS PRESSURE

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Oxygen respiration under excess pressure is widely employed in the practice of medicine. Thus, in avia-
tion it is an effective means of providing oxygen for man at high altitudes (greater than 12 km) in those instances
where the hermetic seal of the airplane's cabin is disturbed.

In clinical medicine respiration under excess pressure is employed during certain regimes for artificial res-
piration, especially during operations on organs in the thoracic cavity; it is also successfully used therapeutically
in acute emphysema and several other illnesses. There is also grounds for postulating that respiration under ele-
vated pressure, inevitably leading to hypertension in the pulmonic circulation, can be used as a functional test
for appraising the reserve potentials of the right heart.

Probably one of the first reports of a change in the blood circulation during rapid, brief elevation of the
intrapulmonic pressure was already made in the XVII century in the work of Valsalva; he noted that elevation of
the intrapulmonic pressure, caused by attempting to exhale against a closed glottis (the Valsalva Maneuver), brought
about a sharp drop in blood flow, up to a temporary complete stop.

In 1853, Donders [8] observed that an increase in the pressure within the lungs inhibits the normal filling of
the heart during diastole, and is a reason for the development of venous congestion. The essential changes in blood
circulation during oxygen respiration under elevated pressure were experimentally established in 1860 by Einbrodt
[9]. In experiments on dogs he found that the pressure in the right auricle and in the veins rose in parallel to ele-
vation of the intrapulmonic pressure. When the intrapulmonic pressure attained 25-30 mm Hg a reduction in the
arterial pressure was observed in the experimental dogs, which along with disruption of respiration, appeared to
be the basic reason for the death of the animals.

It is of definite interest to note Einbrodt's observation [9] pertaining to the appearance of an opposing pres-
sure in the stomach (contraction of the stomach in the experimental animals) which permitted normalization of
the blood circulation during respiration under elevation pressure. In the subsequent works of P. M. Gramenitskii
et al. [2], D. I. Ivanov et al. [4], G. V. Altukhov and N. A. Agadzhanyan [1], in experiments on animals, it was
shown that elevation of the pressure in the lungs inevitably leads to an increase in the intravascular pressure of
the pulmonic circulatory system, the large veins, the right auricle and the right ventricle, as well as the pressure
of the spinal fluid. The arterial pressure rises only with a relatively small elevation in the intrapulmonic pressure—
to 25–30 mm of Hg, and at higher levels it falls. The experiments of G. V. Altukhov and N. A. Agadzhanyan
established that the involvement of a compensatory mechanism, creating a counterpressure in the body during
intensification of the pressure in the lungs, leads to a greater elevation in the venous pressure and the pressure in
the right and left ventricles. This makes it possible to maintain the arterial pressure at a sufficiently high level.
during elevated intrapulmonic pressures. According to the data in the literature, a reduction in the rate of blood flow was observed both in the pulmonic and systemic circulation during oxygen respiration under excess pressure. This was established in investigations on man using the method of decholine injection [6], and on animals by means of injections of radioactive phosphorous [4].

As can be seen from the literature presented, the presence of an excess pressure in the lungs causes essential changes in the hemodynamics. Thus, a study of the blood circulation during respiration under excess pressure has great practical significance.

The purpose of this investigation was to study the blood circulation in man during oxygen respiration under excess pressure. The work was done under terrestrial conditions, both with the use of apparatus exerting counter-pressure on the surface of the body and without the use of these apparatus.

METHOD

Eleven young, healthy males took part in the work; eighteen investigations were carried out. The individuals under investigation breathed oxygen under excess pressure of 8–15, 20–25 and 40 mm Hg and higher. Before the beginning of the investigation the oxygen mask was carefully fitted. The excess pressure in the lungs was created by an oxygen apparatus, permitting the generation of the necessary pressure under the mask and in the pressure system of the compensatory apparatus separately and simultaneously.

In order to evaluate the state of the blood circulation in the subjects we recorded the electrocardiogram (EKG), ballistocardiogram (BKG), pulse volume, plethysmogram, and respiratory excursions of the thoracic cavity; we also determined the levels of the minimal and maximal arterial pressure and the rate of propagation of the pulse wave.

The EKG was recorded from the three standard leads. The BKG was registered on a high-frequency ballistocardiograph (Starr table). The tracing was made during respiratory stops at inspiration and expiration.

To determine the rate of pulse wave propagation we recorded 2 sphygmograms at the same time. We placed pneumatic cuffs at the proximal portion of the thigh and the distal area of the calf of the subjects under investigation, connecting them to piezoelectric crystal datchiki. The plethysmogram recorded from the calf using a tensometric manometer.

RESULTS

It was established that even a relatively small elevation in the intrapulmonic pressure (8–15 mm Hg) causes